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THE EFFECT OF ECHO LENGTH ON SSI BEARING ERROR IN THE PRESENCE --ETC(U)
OCT 63 G T KEMP, J M YOUNG, W A YOUNGBLOOD NOBSR-91039

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TRACOR

TECHNICAL NOTE

THE EFFECT OF ECHO LENGTH ON SSI BEARING ERROR IN THE PRESENCE OF NOISE (U)

Prepared for

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TECHNICAL NOTE

THE EFFECT OF ECHO LENGTH ON SSI BEARING ERROR IN THE PRESENCE OF NOISE (U)

An analytical expression for the rms error of statistically independent bearing measurements as a function of the system input signal-to-noise ratio was developed in the TRACOR redundancy report[1]. The rms errors shown in Figure 18 of that report are for single samples.

However, the effect on bearing error of averaging over several statistically independent samples is of greater practical interest. A single ping permits observation on the SSI of several statistically independent values. The time between independent observations is approximately $\frac{1}{W}$ seconds, where W is the receiving bandwidth in cps. The number of independent observations for each ping is therefore proportional to the echo length.

When an average of several statistically independent observations, n, is made, the standard deviation of the sample mean is $\frac{1}{\sqrt{n}}$ as large as that for the single sample. Thus the situation can be outlined as follows:

1. The system bandwidth W establishes the time interval between statistically independent noise samples as approximately $\frac{1}{W}$ sec.
2. The echo length T determines the length of time during which samples may be obtained.
3. The number of statistically independent samples per

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[1] "Some Redundancy Effects on AN/SQS-26 Performance (U)" TRACOR, Inc. Technical Memorandum of 9 September 1963 Contract NObsr-89265
TRACOR Document Number 63-233-C (~~Confidential~~)

echo is then approximately WT.

4. The standard deviation of the average of the values during an echo is thus $\frac{1}{\sqrt{WT}}$ times the standard deviation for a single value.

Example: W = 150 cps (for the AN/SQS-26C)

Let T = 100 ms

and S/N = 10 db

Then, $\sigma = 0.66$ = the single sample rms bearing error (from Figure 18 of the redundancy report).

$$\sigma_{echo} = \frac{\sigma}{\sqrt{WT}} = \frac{0.66}{\sqrt{(150)(0.100)}} = 0.17^{o}$$

The echo is generally longer than the transmitted pulse since it is reflected from a target of significant size. The amount of lengthening is a function of the target aspect. Representative values for a fleet-type submarine[2] are

Minimum echo lengthening = 6 ms
(beam aspect)

Maximum echo lengthening = 110 ms
(approximately 30° off bow or stern)

Calculations of SSI rms bearing error as a function of signal-to-noise ratio were made for ping lengths of 10, 30, 100, 300, 500, and 1000 ms, using the two extreme values of echo lengthening given above. The results are shown in the two sets of curves in Figure 1. The upper set of curves, for the 6 ms

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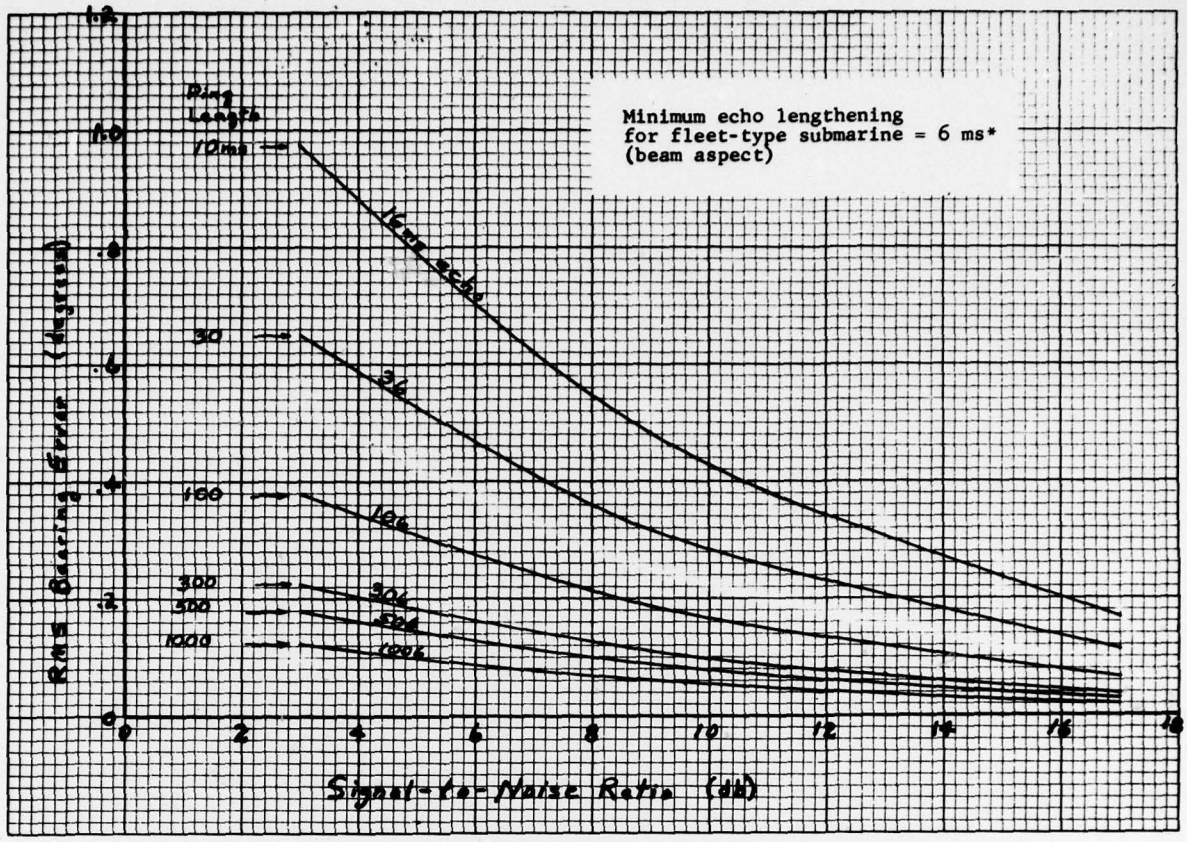
[2] L. Beck, et al, "Submarine Echoes and Wakes...," NAVORD Report 5891, 20 May 1958, p. 31, (CONFIDENTIAL).



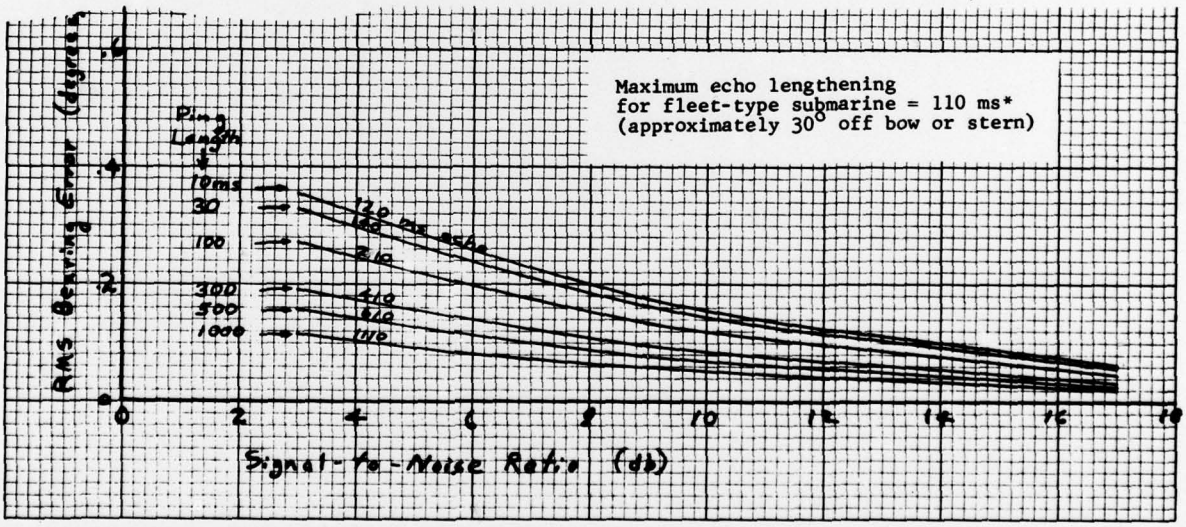


Fig. 1

RMS Bearing Error vs Signal-to-Noise Ratio of echoes for various ping lengths. The longer echoes allow averaging over more statistically independent samples, and reduce the RMS scanning error as $\frac{1}{\sqrt{WT}}$ where T is the echo length (sec) and W is the receiving bandwidth (cps). These curves are derived from the curve of Figure 18 of the TRACOR redundancy report of 9 September 1963, using W = 150 cps.

*L. Beck, et al, "Submarine Echoes and Wakes . . . ," NAVORD Report 5891, 20 May 1958, p. 31.

echo lengthening, shows little significant improvement in rms bearing error over the unlengthened pings except for the 10 ms ping length. However, the additional smoothing of the 110 ms echo lengthening is quite significant for the 10, 30, and 100 ms pings, as is seen in the lower set of curves in Figure 1. In fact, for a signal-to-noise ratio of 14 db (for tracking operation) the SSI rms bearing error due to noise does not exceed 0.1°. In reality, the pulse lengthening will usually lie between 6 and 110 ms; therefore, the rms bearing error will lie between those indicated in the two sets of curves of Figure 1.

Figure 2 shows the rms bearing error of the SSI as a function of echo length for various input signal-to-noise ratios. These curves are cross-plots of rms bearing error vs signal-to-noise ratio. The rms bearing error for echoes of any duration less than 1.0 sec may be obtained from Figure 2 if the signal-to-noise ratio at the input to the SSI is known. The bandwidth applicable for these curves is 150 cps, consistent with that specified for the AN/SQS-26C.

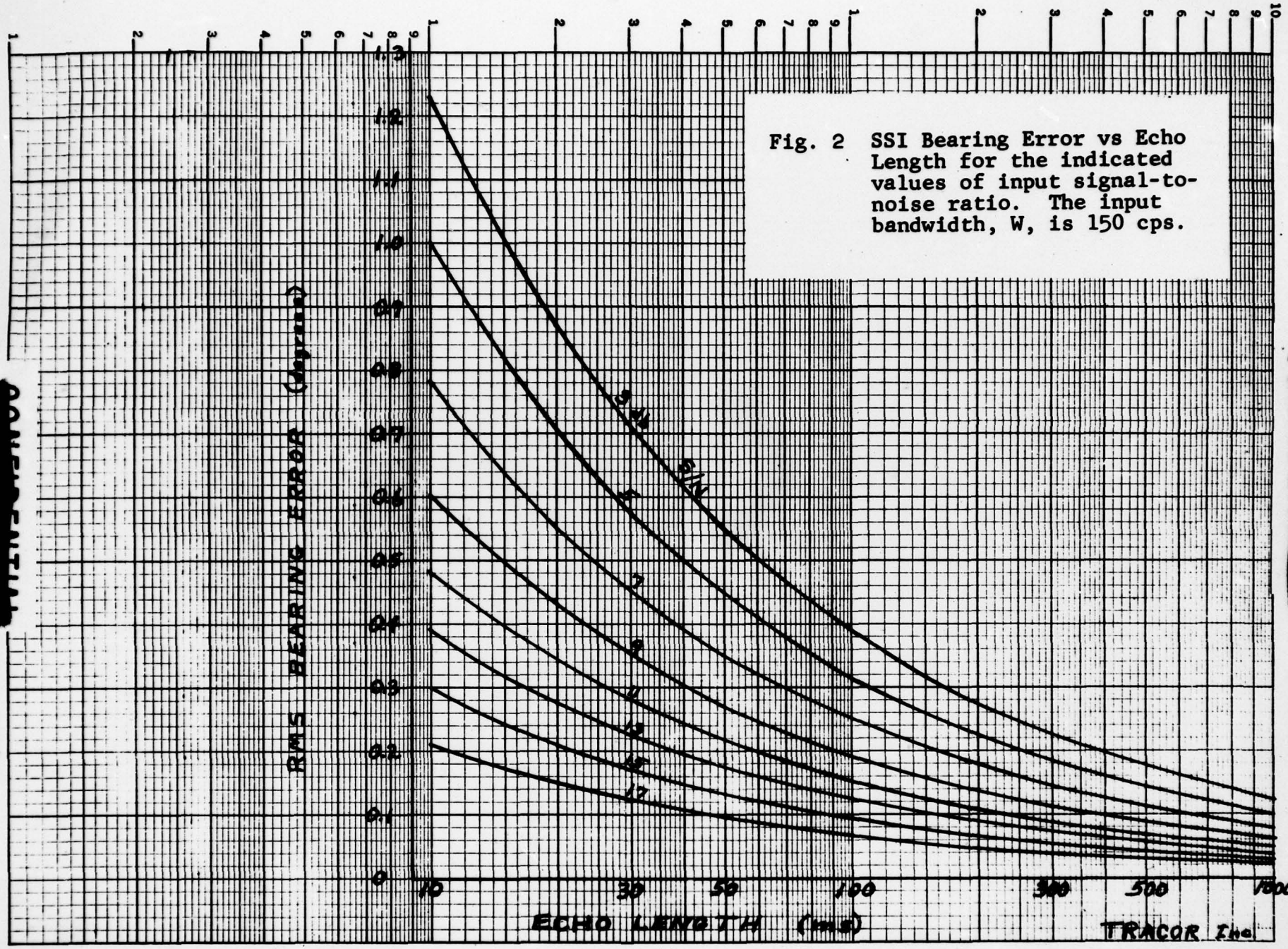


Fig. 2 SSI Bearing Error vs Echo Length for the indicated values of input signal-to-noise ratio. The input bandwidth, W, is 150 cps.